Cracking the AQ Code

ADEQ Arizona Department of Environmental Quality
Air Quality Forecast Team

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$PM_{2.5}$ in Arizona and around the World

By: Jonny Malloy, Pratik Patel, Ryan Nicoll, and Michael Graves (ADEQ Air Quality Meteorologists)

$PM_{2.5}$ in Arizona and around the World

You may have noticed that ADEQ's team of meteorologists issue air quality forecasts for multiple pollutants at a time. For instance, the Phoenix daily air quality forecast discusses ozone (O_3), coarse particulates (PM_{10}), and fine particulates ($PM_{2.5}$). You'll find that there are common threads between us and other parts of the world when it comes to dealing with pollutants. Air quality concerns are not exclusive to Arizona or the United States.

In a prior issue of *Cracking the AQ Code*, "Dust in Arizona and around the World", PM_{10} was the focus. That topic addressed dust

Figure 1: Map showing locations of 127 Automated Urban and Rural Network monitors in the United Kingdom. Source: Department for Environmental Food and Rural Affairs.

About "Cracking the AQ Code"

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In an effort to further ADEQ's mission of protecting and enhancing the public health and environment, the Forecast Team has decided to produce periodic, in-depth articles about various topics related to weather and air quality.

Our hope is that these articles provide you with a better understanding of Arizona's air quality and environment. Together we can strive for a healthier future.

We hope you find them useful!

Upcoming Topics…

- Carbon Monoxide: The Pollutant of Yesterday
- Tools of the Air Quality Forecasting Trade: Satellite Imagery

experienced in Arizona relative to other desert regions on earth. This latest issue turns the spotlight onto $PM_{2.5}$, or fine particulates like soot. The Phoenix area will be compared to $PM_{2.5}$ levels recognized at three large cities: London, New Delhi, and Beijing. The goal is to highlight that air pollution really is a universal affair when it comes to human health.

London, United Kingdom

Our first stop takes us to the United Kingdom. Particularly unhealthy smog events related to industry in the mid-20th century triggered the United Kingdom's Clean Air Act in 1956. Shortly thereafter, a network of pollutant monitors called the National Survey was created, numbering over a thousand locations. Such action made the U.K. the first country to track air quality in such a vast and organized manner. Objectives of that network were to determine black smoke and sulfur dioxide levels tied to industrial activity.

Since then the monitoring network has evolved into today's Automatic Urban and Rural Network (AURN) (Figure 1), emphasizing ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, and particulate matter. Hourly observations in recent years have totaled over four million annually. Similar to the United States, it is clear that the state of air quality is taken quite seriously for the European nation.

Focusing on London, the condensed nature of city life with endless heavy traffic has been linked to air quality issues (Figure 2). After all, it is the 32nd largest urbanized area in the world with a population exceeding ten million. Fortunately, residents of Greater London benefit from the London Air Quality Network (Figure 3) to keep them aware of multiple pollutant trends, including $PM_{2.5}$.

Figure 2: London experiencing poor air quality and reduced visibility on April 30, 2014. Source: *David Holt*.

Figure 3: PM2.5 observation locations in Greater London associated with the London Air Quality Network (LAQN). Source: *London Air.*

Recommended Actions and Health Advice

Air Pollution Banding	Value	Accompanying health messages for at-risk individuals*	Accompanying health messages for the general population
Low	1-3	**Enjoy** your usual outdoor activities.	**Enjoy** your usual outdoor activities.
Moderate	4-6	Adults and children with lung problems, and adults with heart problems, **who experience symptoms**, should **consider reducing** strenuous physical activity, particularly outdoors.	**Enjoy** your usual outdoor activities.
High	7-9	Adults and children with lung problems, and adults with heart problems, should **reduce** strenuous physical exertion, particularly outdoors, and particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also **reduce** physical exertion.	Anyone experiencing discomfort such as sore eyes, cough or sore throat should **consider reducing** activity, particularly outdoors.
Very High	10	Adults and children with lung problems, adults with heart problems, and older people, should **avoid** strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often.	**Reduce** physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat.

Index	1	2	3	4	5	6	7	8	9	10
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very High
μgm^{-3}	0-11	12-23	24-35	>36-41	>42-47	>48-53	54-58	59-64	65-70	71 or more

Figure 4: Health messaging tied to the United Kingdom's Daily Air Quality Index (DAQI). The bottom graphic bar shows how PM2.5 concentrations directly correspond to a respective DAQI Index Band. Source: *Department for Environmental Food and Rural Affairs*.

In addition to readily available monitoring observations, Londoners can sign up for an emailed pollutant forecast or receive forecasts through a mobile app. Both options are available for us in Phoenix, too (i.e., GovDelivery subscriptions and Clean Air Make More app). One key difference, however, is that forecasted values for our British counterparts are conveyed to them using the Daily Air Quality Index (DAQI), which tiers pollutant concentrations within four categories from "Low" to "Very High" (Figure 4). Collectively, the categories indicate ten "Index Bands" with a *10* associated with the worst air quality. Despite differences between our familiar Air Quality Index (AQI) used stateside, the U.K. and U.S. both determine appropriate air quality indices for $PM_{2.5}$ based on observed (or forecasted) concentrations in units of µg/m^3.

To give perspective against the forecast products you may be accustomed to seeing from ADEQ, Fig. 5 shows an example of an air quality forecast someone from London would read. Official forecasts for air quality across the United Kingdom are provided by the Department for Environmental Food and Rural Affairs (Defra), but created by meteorologists on staff at the Met Office.

Now that we know about London air quality monitoring and forecasting availability, let's take a deeper dive into $PM_{2.5}$ concentrations found there. Through modelling efforts, it has been determined that those living in interior parts of the city would receive the greatest exposure to fine particulates (Figure 6), which can be said for most bustling urban cities.

Figure 5: An air quality forecast issued November 2, 2016, for the London area. Source: London Air.

Furthermore, an increased likelihood of elevated particulate concentrations near roadways is evident by Fig. 7 (zoomed image of Figure 6). According to London Air, "particles originating from road traffic include carbon emissions from engines, small bits of metal and rubber from engine wear and braking as well as dust from road surfaces. Others include material from building and industry as well as wind-blown dust, sea salt, pollens and soil particles." Besides sea salt, the same sources of particulates can be said about our local area.

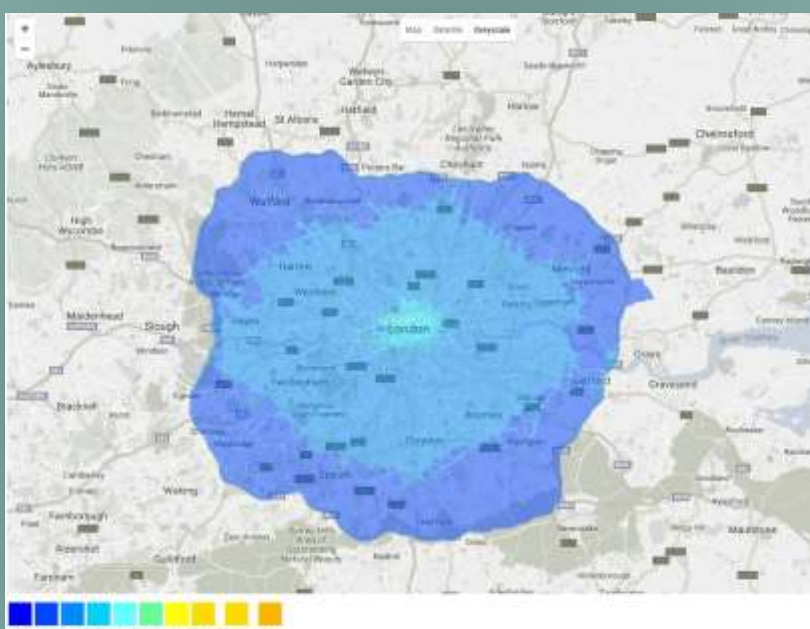

Figure 6: Modelled annual mean $PM_{2.5}$ concentrations (2013) for Greater London. Annual average concentrations are comparable to those observed in the Valley of the Sun. Source: London Air.

As you can see in Fig. 2, London does deal with periodic air quality episodes, weather and human caused. Specific to particulates, local accumulation under weak winds and winter inversions can be common, just like in Arizona. London coins these as "winter smog" scenarios. Weak winds are also ideal for "summer smog" environments, though strong inversions may be absent. Summer smog cases have the added health hazard of elevated ozone concentrations due to abundant ozone precursors chemically reacting over the course of greater day lengths. Extended stagnation leading to unhealthy air quality is always watched for by practicing air quality meteorologists, regardless of season.

Long range transport is something that needs to be anticipated, too. Prevailing winds from mainland Europe have been documented for [importing pollutants]() and degrading London air quality. Although relatively rare, even Saharan dust has been found to intrude the skies of London and affect ground-level particulate concentrations (Figure 8). Otherwise, air quality in general improves near London when "fresh" air arrives directly from the Atlantic Ocean. Another long range transport concern is wildfire smoke from Russia. We deal with periodic wildfire plumes in the western United States, so we can relate to that aspect. A fourth and much less frequent type of long range particulate transport is volcanic ash plumes. The U.K., and much of Europe for that matter, was influenced by the eruption of Icelandic volcano Eyjafjallajökull in 2010 (Figure 9). Fortunately, in this instance, U.K. air quality was [not adversely affected](), although the presence of the ash cloud could be seen in the skies (Figure 9).

Figure 7: Modelled annual mean $PM_{2.5}$ concentrations (2013) for Greater London showing highest concentrations near roadway corridors (yellow lines). Source: *London Air*.

Figure 8: NOAA HYSPLIT backward air parcel trajectory (in six hour increments) tracing observed dust in London between January 23rd and the 24th, 2008, originating from dust in North Africa on January 19th. Source: *London Air*.

Figure 9: Eruption of Eyjafjallajökull in Iceland seen at ground-level (left), long-range transport of ash plume viewed from space (center), and volcanic ash seen at sunset at Leeds-Bradford Airport, England (right). Photos: *Árni Friðriksson* (left), *NASA* (center), and *TJBlackwell* (right).

A third category that forces higher particulate levels are holiday celebrations. In the U.K., excessive particulate concentrations are linked to Guy Fawkes, Diwali, and Bonfire Night festivities. Fireworks and recreational fires are prevalent during celebrations, and under the right atmospheric environment, add significantly to observed surface pollutant levels.

When we circle back to $PM_{2.5}$ in Arizona, it will be shown that Phoenix experiences recurring air quality impacts on Christmas Eve, Christmas Day, New Year's Eve, and New Year's Day. Enjoying the holidays using alternative burning methods (e.g., natural gas) or simply choosing not to burn wood can go a long way towards improving air quality on those historically poor air quality days. Your neighbors may end up thanking you for the effort! More details on how to make a difference can be found by checking out the Burn Cleaner Burn Better campaign underway in the Phoenix area:

http://cleanairmakemore.com/noburn/ and http://www.azdeq.gov/BCBB.

Figure 10: Image of the earth centered over India with the star indicating the location of New Delhi, India. Source: *Google Earth*

New Delhi, India

Our next destination on the $PM_{2.5}$ world tour is New Delhi, India (see Figure 10). As you have just seen, there are other places around the world that often experience poor air quality due to industrial and/or residential activity. Unfortunately, an extreme example of one of these places is New Delhi, India. In 2013, the average $PM_{2.5}$ concentration in the city for the year was 153 µg/m^3. These levels, which can be seen in Table 1 below, are considered Very Unhealthy under the U.S. Environmental Protection Agency's (EPA) Air Quality Index (AQI).

Table 1: Air Quality Index table developed by the U.S. Environmental Protection Agency (EPA). The table displays the necessary breakpoints with the most recent pollutant standard.

Environmental Protection Agency (EPA) Air Quality Index					
Category	AQI	PM_{10} µg/m³ 24-hr avg	$PM_{2.5}$ µg/m³ 24-hr avg	CO ppm 8-hr avg	O_3 ppb 8-hr avg
Good	0-50	0-54	0-12.0	0-4.4	0-54
Moderate	51-100	55-154	12.1-35.4	4.5-9.4	55-70
Unhealthy for Sensitive Groups	101-150	155-254	35.5-55.4	9.5-12.4	71-85
Unhealthy	151-200	255-354	55.5-150.4	12.5-15.4	86-105
Very Unhealthy	201-300	355-424	150.5-250.4	15.5-30.4	106-200
Hazardous	301-500	425-604	250.5-500.4	30.5-50.4	Does not exceed 300 AQI

However, the AQI table used to indicate the state of air quality is different in India. The Ministry of Earth Science, Government of India uses the following table with only five categories: Good, Moderate, Poor, Very Poor, and Severe (Table 2).

Table 2: The Air Quality Index table used by the Ministry of Earth and Science informs Indians the state of air quality in their cities. In addition to having just five categories, instead of the six categories used by EPA in the United States, each category also has a higher threshold for concentrations. Source: *System of Air Quality and Weather Forecasting and Research (SAFAR)*

Description	AQI	PM10 µg/m³ 24 hr avg	PM2.5 µg/m³ 24 hr avg	CO ppm 8 hr avg	O3 ppb 8 hr avg
Good + Satisfactory	0-100	0-100	0-60	0-1.7	0-50
Moderate	101-200	101-250	61-90	1.8-8.7	51-84
Poor	201-300	251-350	91-120	8.8-14.8	85-104
Very Poor	301-400	351-430	121-250	14.9-29.7	105-374
Severe	401-500	431-550	251-350	29.8-40	375-450

In a developing country filled with 1.3 billion people, the major city of New Delhi, with an area of 573 square miles, is densely packed with a population of around 22 million people. Just to put it perspective, Arizona, with its area of 114,000 square miles, has a population of 6.7 million people. A primary reason air quality becomes an issue is because all of these people require energy to survive just like the rest of us.

When it comes to energy, coal is the primary source of fuel used to supply the increasing demand for energy in India due to its availability and low-cost. Unfortunately, coal is a dirty fuel source that worsens air pollution. In addition, transportation also grows as cities develop and expand. Motor vehicle emissions are one of the primary causes of poor air quality in New Delhi. Coupled with heavy and congested traffic, idling vehicles expel tons of pollution every day.

Like many parts of the world, topography and weather play a major role when it comes to air quality in a region. Compared to its surroundings, New Delhi is in a low lying area. During the winter months when temperature inversions are common and often stronger, pollution generated near the surface tends to remain trapped closer to the ground. As a result, the city becomes blanketed in a smog and haze that can last several hours of the day (Figure 11).

Figure 11: Heavy smog blankets New Delhi, India

Source: *Inhabitat*

The city of Delhi's government has been trying to implement various solutions in order to combat the poor air quality and protect the health of its citizens. Some of these solutions are: prohibiting the use of diesel generators during the week, vacuum-cleaning roads, stricter enforcement on burning leaves and garbage, watering roads to reduce dust particles in the air, and introducing the odd-even program to thin out traffic. Since traffic is one of the bigger contributors of poor air quality, the government has assigned days when cars with odd and even license plate numbers can be on the road. Even though air quality in New Delhi is still terrible compared to places like the United States, the city has come a long way in improving pollution levels over the past few years.

Beijing, China

On our last stop around the world before heading back to Arizona, we will take a look at the noticeable impact $PM_{2.5}$ has had on the city of Beijing, China. China is probably one of the more common locations known to have particulate issues, especially after all the publicity it received during the 2008 summer Olympics hosted in Beijing, China. While many of the highly populated regions in China have issues with pollution, we will be focusing on the capital of China—Beijing.

Figure 12: Image of the earth centered over China with the star indicating the location of Beijing, China. Source: *Google Earth*

Located in northeast China (Figure 12), Beijing has a population over [21 million people](). For comparison, the entire Phoenix metropolitan area is approaching five million people, and the city itself has a little over [1.5 million]() (as of 2015). With so many people concentrated in one area, it's no wonder $PM_{2.5}$ has become a major concern for the region. Similar to most locations, the cooler months see the highest concentrations of fine particulates, largely due to inversions. The sources of particulates include vehicles, burning for heating, as well as power generation and industry. While this is true for

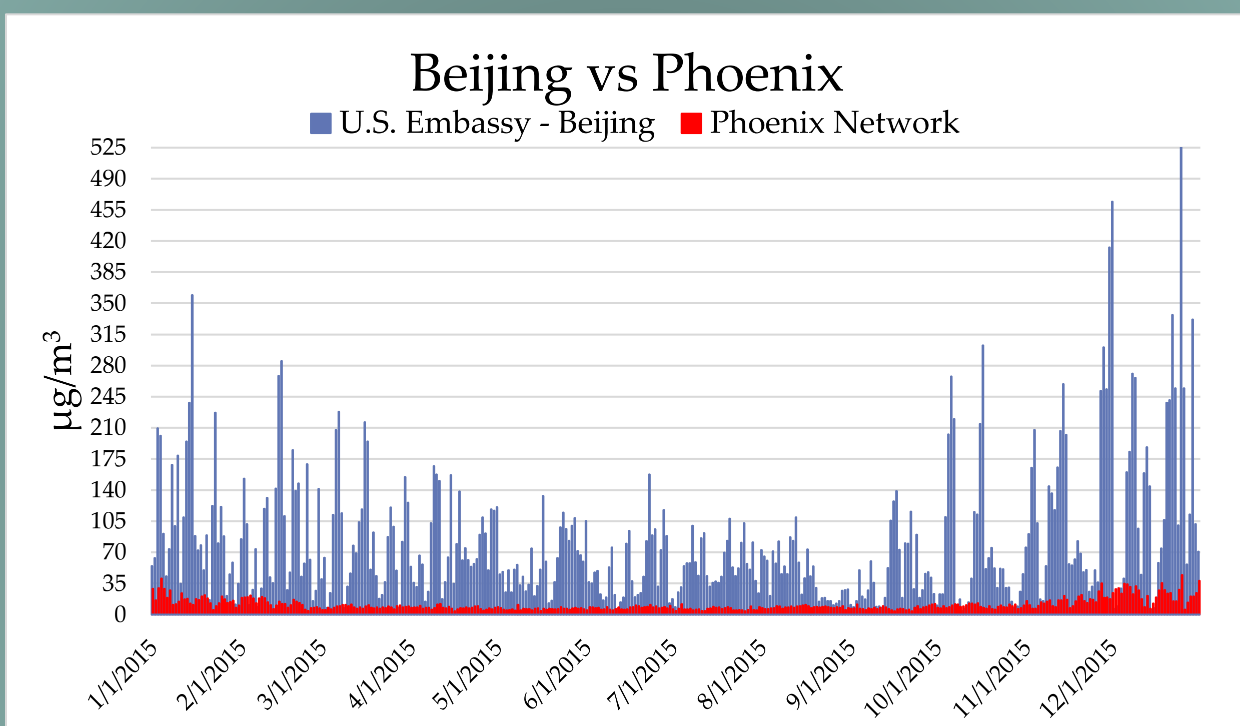

Figure 13: Graph of the 2015 daily 24hr average $PM_{2.5}$ concentrations from a monitor at the U.S. embassy in Beijing (blue) and our own Phoenix monitoring network (red).

many regions, due to the sheer size of Beijing, the scale of these activities are so much greater than most parts of the world.

The graph above (Figure 13) compares $PM_{2.5}$ data from a U.S. embassy in Beijing to the Phoenix monitoring network here. As you can see, they both follow a similar trend with higher concentrations in the winter and lower concentrations in the summer. However, you can clearly see that the values are very different. The concentrations in Beijing are typically several times higher than what we see here in Phoenix.

Figure 14: Photo of the poor air quality in Beijing, China on December 25, 2015. A Red Alert had to be issued as a result. Source: *ChinaFotoPress via Getty Images*

There is no denying that China has some serious air pollution issues. However, in recent years they have begun taking steps to improve their air quality by shutting down old factories, reducing public transportation costs, increasing the availability of public transportation, and banning high-emission vehicles. Another major policy they have implemented is restricting driving on certain days. Similar to New Delhi's policy, drivers are assigned certain days they can drive based on their license plate number. This policy was enforced before the 2008 Beijing Olympics to help clean the air before the games and continues to be enforced during air quality Red Alerts (Figure 14).

China's alert system, used in the heavily polluted cities of China, is a four-color alert system: blue, yellow, orange, and red (Table 3). Although the colors are similar, this system should not be confused with our AQI. Instead, alerts are only issued under poor air quality episodes. In that regard, alerts are more like our High Pollution Advisories and Health Watches. China's highest alert, the Red Alert, goes into effect only when the AQI is above 500 for one day, above 300 for two consecutive days, or above 200 for four consecutive days. Looking at $PM_{2.5}$ data going back over a decade, Phoenix has not come close to

Table 3: The table below shows China's four air quality alert levels and the conditions necessary for each alert.

Alert Color	Condition
Blue	AQI 201-300 in the next 24 hours
Yellow	AQI 301-500 in the next 24 hours; or AQI 201-300 for three consecutive days
Orange	Alternate AQI 201-300 and AQI 301-500 for three consecutive days
Red	AQI 201-300 for four consecutive days; or AQI 301-500 for two consecutive days; or AQI greater than 500 for one day

China’s Red Alert conditions. We have only reached Blue Alert criteria twice during this time period, both on New Year’s Day due to holiday activities. While China obviously still has pollution issues, the policies and alert system they have implemented will hopefully lead to healthier air in the future.

Phoenix, Arizona

So far, we have learned about $PM_{2.5}$ in three different continents outside of North America. Now, we finally bring it back home to Arizona, specifically, to Phoenix. One of the perks of living in Phoenix is the wintertime. How many Americans can say that they enjoy high temperatures in the 60s and 70s during the middle of December or January? However, not even winters are perfect in Phoenix. Regarding air quality, Phoenix is plagued by higher $PM_{2.5}$ levels during the winter months. In fact, a looming haze, particularly close to the mountains south of the Valley, can be a daily sight. The dirty appearance of the atmosphere within the Valley ultimately culminates in what locals call, “the brown cloud” (see Figure 15). In this section, we’ll explore $PM_{2.5}$ in Phoenix and gain a better understanding of why Phoenix has an air quality problem in the winter months.

Figure 15: A view of downtown Phoenix enveloped by the infamous “brown cloud” from atop Camelback Mountain, just before sunset, on December 9, 2015. A PM2.5 Health Watch was issued on this day. Photo by: *Michael Graves*

$PM_{2.5}$ throughout the Year

Phoenix, like all the cities we’ve looked at, has a seasonal $PM_{2.5}$ pattern. Take a look at the graph in Fig. 16. Each bar represents the average number of days in a given month on which a $PM_{2.5}$ monitor has reached a Moderate AQI or higher in the Valley. Notice how January, February, November, and December

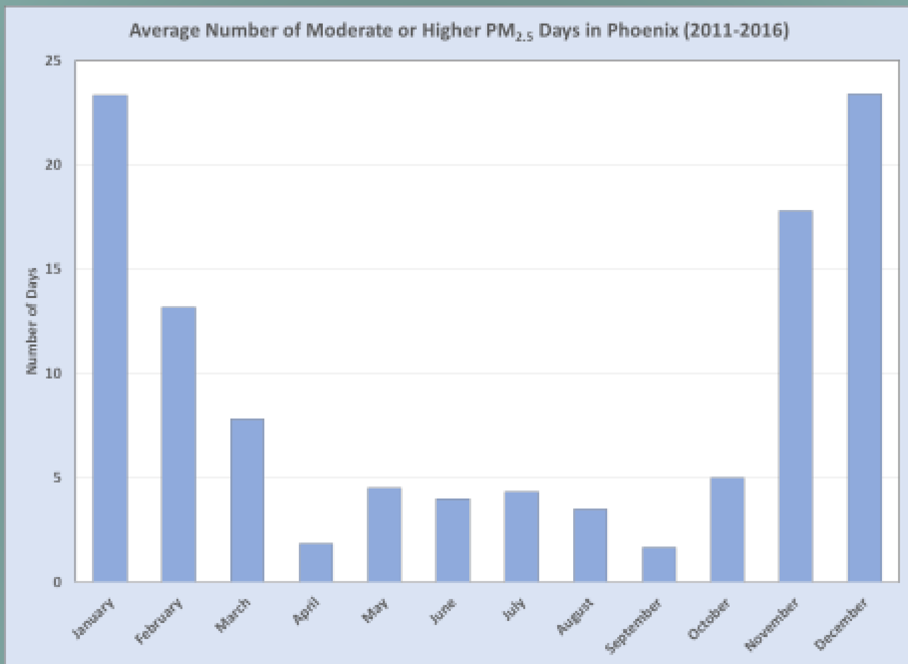

Figure 16: A bar graph showing the average number of days, per month, on which PM2.5 reached an AQI value in the Moderate category or higher in Phoenix.

all clearly have a greater amount of Moderate or worse $PM_{2.5}$ days than the rest of the months. The other side of the coin is that Moderate $PM_{2.5}$ days are typically uncommon during the warmer months of the year. Overall, Moderate $PM_{2.5}$ levels are possible in every month, but are more common during colder months.

$PM_{2.5}$ in the Warm Season

During the months that don't usually see elevated $PM_{2.5}$ levels (March-October), Moderate or higher $PM_{2.5}$ levels are the result of specific weather events or abnormal occurrences. For example, in the transition seasons of spring and fall, there is an increase in the frequency of weather systems that impact Arizona from the west. Often, these systems are dry and only affect Phoenix with winds (see Figure 17). These "dry wind events" can result in increased dust activity, leading to higher PM_{10} and $PM_{2.5}$ levels. Furthermore, if weather conditions become stagnant following the system, higher $PM_{2.5}$ levels could linger and lead to additional days of elevated $PM_{2.5}$ levels.

Figure 17: Early morning on May 11, 2014, a cold front passed through Phoenix. The image on the left shows a view of Camelback Mountain from [ADEQ](#) at 7 AM on May 10th. The right image is the same view, at the same time of day, but on May 11th. Camelback Mountain is completely obscured by particulates in the air in the left image. Both PM_{10} (dust) and $PM_{2.5}$ were transported into Phoenix from California and Nevada.

In the summer, weather systems from the west are still possible, but the monsoon becomes the main player in elevating $PM_{2.5}$ levels. The primary weather event responsible for higher $PM_{2.5}$ then becomes dust storms. Though dust storms are known to raise PM_{10} (dust) levels, they can do the same for $PM_{2.5}$. On occasion, dust storms can be strong enough to result in $PM_{2.5}$ exceeding the federal health standard. Another source of $PM_{2.5}$ in the summer is wildfires. If close enough to the Valley and if winds are favorable, smoke from wildfires can move into the Valley and increase $PM_{2.5}$. Lastly, every once and a while, local happenings such as fires from industrial plants can put up smoke and $PM_{2.5}$ into the Valley's air. Such local events are impossible to anticipate and can thwart $PM_{2.5}$ forecasts by ADEQ's Forecast Team.

$PM_{2.5}$ in the Cold Season

So, you might be wondering, why does Phoenix have high $PM_{2.5}$ levels in the winter? The state of $PM_{2.5}$ in Phoenix during the winter is a product of the combination of several factors: dry climate, terrain, and relatively infrequent weather systems. In a previous issue of *Cracking the AQ Code*, we discussed the "nocturnal inversion", which is a layer of colder air near the surface and warmer air just above. The inversion acts as a lid, keeping stronger winds up higher in the atmosphere, and reinforcing calm conditions near the ground at night. In a dry climate, temperatures are able to cool more during the nighttime (there is less moisture to help moderate the temperature). So, colder air near the ground will only help to strengthen the nocturnal inversion. A stronger inversion then leads to $PM_{2.5}$ remaining trapped closer to the ground for a longer period of time in the morning. This is why the air typically looks dirtiest in

Figure 18. A view of the Valley from ADEQ's South Mountain webcam looking southward towards downtown Phoenix, mid-morning on December 2, 2015. The inversion is situated just above the layer of pollution. The location of Downtown Phoenix is indicated by the arrow.

the morning hours (see Figure 18). Moreover, it is certainly possible for the inversion to stick around all day, rising during the daytime and sinking toward night as the ground begins to cool.

Phoenix's terrain also plays a significant role in influencing $PM_{2.5}$. In the picture in Fig. 15, notice how the top of the brown cloud layer appears just below the top of the mountains in the area (South Mountain to the left, the Estrella Mountains in the back). So, not only is the inversion containing $PM_{2.5}$ from the top, but the mountains are containing it on its southern extent. A map of the Valley's terrain is shown in Fig. 19. Although the mountains do not form a symmetrical valley, they do play a large role in holding in $PM_{2.5}$. The effect of the mountains can also enhance the inversion.

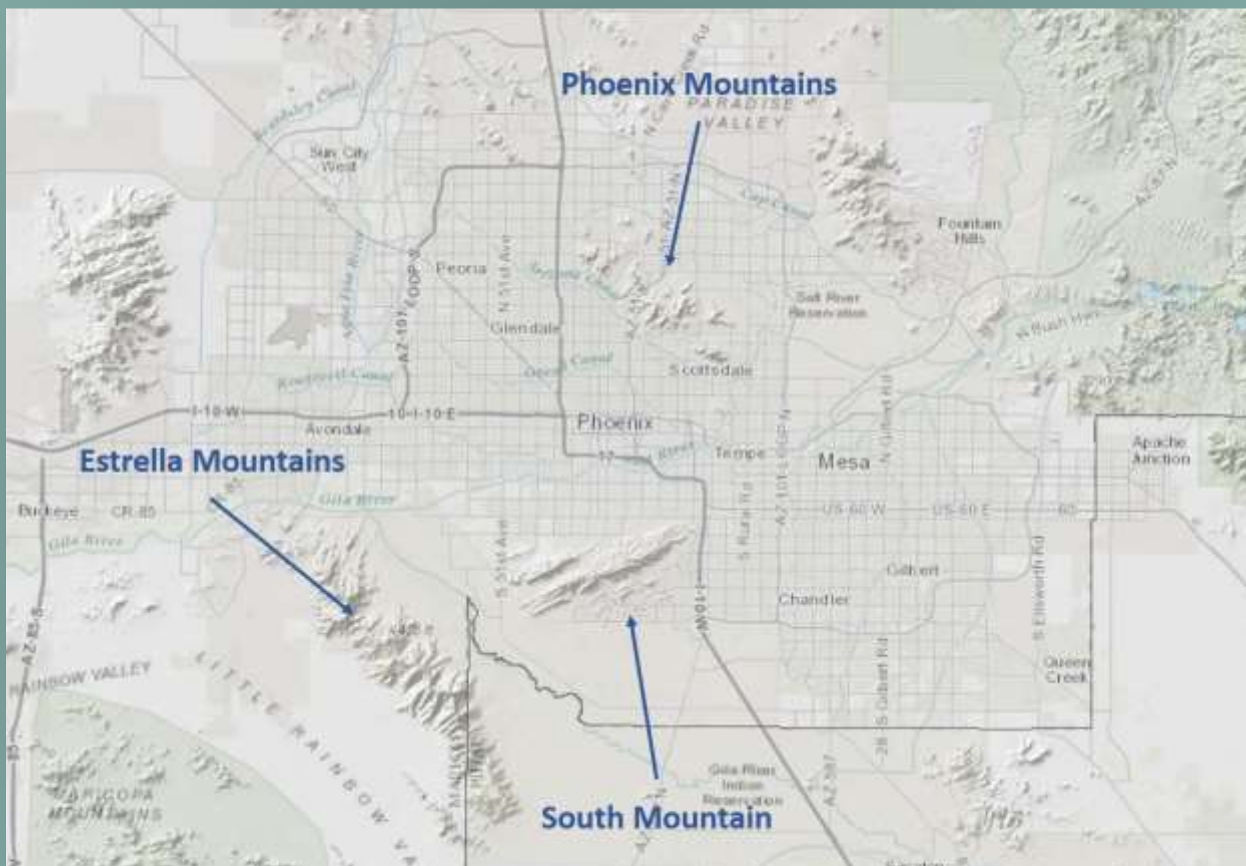

Figure 19: A map the Valley showing terrain, major highways, streets, and county lines. When the nocturnal inversion sinks below the top of the mountains, the mountains act as walls, keeping $PM_{2.5}$ contained over the Valley. South Mountain to the south of Phoenix, the Estrella Mountains to the southwest, and the Phoenix Mountains in central Phoenix can all play a role in containing $PM_{2.5}$ in Phoenix. Map created using ArcGIS. Basemap source: *Esri.*

Lastly, the relatively infrequent nature of weather systems affecting Phoenix allows $PM_{2.5}$ to continue to accumulate on a day-to-day basis. When forecasting for $PM_{2.5}$ in Phoenix, air quality meteorologists at ADEQ keep an eye out for weather systems. Appropriately, we call these weather systems "clearing events" because they help to clear the Valley's air of pollutants. For example, on December 12, 2015 (a few days after the image in Figure 15 was taken), a strong, low pressure trough swept through the Southwest, resulting in breezy wind conditions in Phoenix for most of the day. After 24 straight days of $PM_{2.5}$ levels reaching the Moderate AQI range, Phoenix finally had a day in which every $PM_{2.5}$ monitor reported in the Good AQI range.

Fig. 20 shows a comparison between webcam photos of the Estrella Mountains taken at 12:30 PM on December 11th (top) and December 12th (bottom). Notice how the brown haze in the foreground of the Estrella Mountains on the 11th disappears on the 12th, thanks to the weather system. There were only three such systems to pass through the region in December 2015. Thus, only three days in the month of December saw $PM_{2.5}$ levels in the Good AQI range.

Figure 20: Images of the Estrella Mountains taken by one of ADEQ's webcams on December 11, 2015 (top) and December 12, 2015 (bottom). The brown haze in the foreground of the mountains on the 11th is the typical view in the cooler months as $PM_{2.5}$ accumulates due to the nocturnal inversion and the mountains. However, occasionally, a weather system will come through and clear out the air, which happened on the 12th.

Holidays

Aside from the occasional significant dust storm that can cause $PM_{2.5}$ to exceed the federal health standard, there are four big days of the year on which we can usually count on seeing $PM_{2.5}$ exceed the health standard, if winds are light and weather is not active: Christmas Eve, Christmas Day, New Year's Eve, and New Year's Day. This happened in the winter of 2013-2014. Fig. 21 shows a graph of the maximum daily average $PM_{2.5}$ concentration in Phoenix from June 1, 2013 to June 1, 2014. Notice how the two largest "spikes" coincide with Christmas Day and New Year's Day.

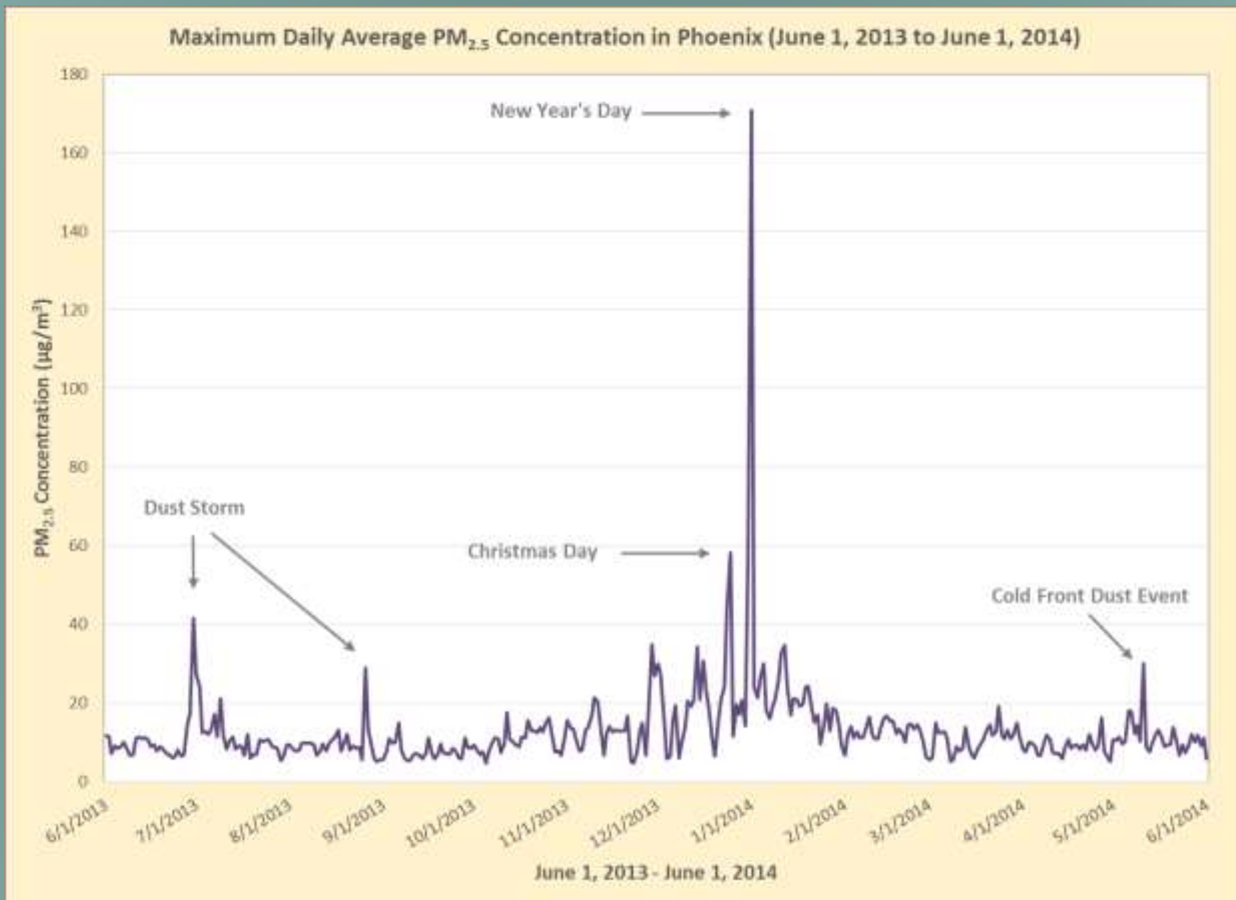

Figure 21: The maximum daily average $PM_{2.5}$ concentration observed from Phoenix's air quality monitoring network from June 1, 2013 to June 1, 2014. This time period was chosen to place the holidays closer to the middle of the graph. $PM_{2.5}$ levels on the holidays can be compared with days that saw elevated $PM_{2.5}$ levels due to weather phenomena.

In the case of the Christmas holiday, $PM_{2.5}$ comes from fireplace usage as people want to create a festive ambiance on the evening before Christmas. Smoke then sticks around through the morning hours of Christmas Day. New Year's Eve is a whole different animal. It is evident that fireworks play a role in contributing to $PM_{2.5}$ concentrations in the Valley's air. Combine that with the overnight inversion, fireplace usage, and calm conditions, and you create a unique scenario of exceptionally high $PM_{2.5}$ levels. Even dust storms don't seem to be able to match this caliber of $PM_{2.5}$. Fortunately, when weather is active, it can prevent $PM_{2.5}$ from exceeding the health standard during the holidays in Phoenix.

Not Alone

After our trip around the world, we have ultimately seen that Phoenix is not alone when it comes to elevated $PM_{2.5}$ levels. In fact, though Phoenix may occasionally (but briefly) see some of the worst air quality in the United States, it doesn't hold a candle to the air pollution found in other parts of the world. We have also seen that other countries recognize the need to regulate their air quality, just like the U.S. They have established programs to curb $PM_{2.5}$ levels and warn the public when $PM_{2.5}$ is expected to be adverse to human health. In the same way, the ADEQ Forecast Team seeks to keep the public in Phoenix (and around Arizona) informed on the air quality and how it is changing. We hope you have enjoyed this latest issue of *Cracking the AQ Code* and have gained some insight into $PM_{2.5}$!

We hope you enjoyed learning a little more behind the scenes information about prescribed burns in Arizona!

Sincerely,

The ADEQ Forecast Team

ForecastTeam@azdeq.gov

If you haven't already, click HERE to start receiving your Daily Air Quality Forecasts (Phoenix, Yuma, Nogales)

In case you missed the previous Issues…

June 2015: Tools of the Air Quality Forecasting Trade: Capturing Dust Storms on Doppler Radar
July 2015: Ozone: An Invisible Irritant
September 2015: North American Monsoon
October 2015: The Genesis of a Thunderstorm: An Arizona Perspective
December 2015: Temperature Profiles, Inversions, and NO BURN DAYS
January 2016: El Niño Southern Oscillation
February 2016: All About Fog
April 2016: Jet Streams and Fronts
May 2016: Consequences of the New Ozone Standard Change
July 2016: Tools of the Air Quality Forecasting Trade Part 2: Predicting and Tracking Wildfire Smoke
August 2016: Dust in Arizona and Around the World
September 2016: Tropical Cyclones
October 2016: Arizona Tornadoes
November 2016: Arizona Prescribed Burns

Here's a look at what we'll be discussing in the near future…

-Carbon Monoxide: The Pollutant of Yesterday
-Tools of the Air Quality Forecasting Trade: Satellite Imagery

Arizona Department of Environmental Quality
Air Quality Forecast Team

1110 W. Washington Street Phoenix, Arizona 85007 ForecastTeam@azdeq.gov